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<p>(54) Title: USE OF GROWTH HORMONE</p> <p>(57) Abstract</p> <p>The invention relates to the use of growth hormone, preferably human growth hormone or analogues thereof for the manufacturing of a medicament for treatment of individuals with the Metabolic syndrome. They include individuals with abdominal/visceral obesity and its metabolic and circulatory consequences including insulin resistance, lipoprotein aberrations and hypertension. The medicament is also used to increase insulin sensitivity and for treatment and prevention of non-insulin dependent diabetes mellitus.</p>		

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USE OF GROWTH HORMONE

The present invention relates to the use of growth hormone, preferably human growth hormone or analogues thereof for the manufacturing of a medicament for treatment of individuals with the Metabolic syndrome (also labeled Syndrome X). They include individuals with abdominal/visceral obesity and its metabolic and circulatory consequences including insulin resistance, lipoprotein aberrations and hypertension. The medicament is also used to increase insulin sensitivity and for treatment and prevention of non-insulin dependent diabetes mellitus.

Introduction

Striking similarities exhibits between The Metabolic Syndrome ^{1, 2} (also labeled Syndrome X or Primary Insulin Resistance Syndrome) and untreated GH deficiency in adults ³. The most central findings in both these syndromes are abdominal/visceral obesity and insulin resistance ^{1, 4-6}. Other features common to both conditions are high triglyceride and low high-density lipoprotein cholesterol concentrations, an increased prevalence of hypertension, elevated levels of plasma fibrinogen and plasminogen activator inhibitor-1 activity, premature atherosclerosis and increased mortality from cardiovascular diseases ^{1, 4, 7-11}.

The Metabolic Syndrome is associated with multiple endocrine abnormalities. They include increased cortisol secretion, blunted secretion of gonadotrophins and sex steroids and abnormalities in the GH/insulin-like growth factor-I (IGF-I) axis ¹²⁻¹⁴. With increased adiposity GH secretion is blunted with decreased mass of

GH secreted per burst but without any major impact on GH secretory burst frequency¹⁵. The serum IGF-I concentration is principally GH dependent and influences GH secretion through a negative feed-back system¹⁶. The serum levels of IGF-I are inversely related to the percentage body fat¹⁵. In addition, we have
5 previously shown that the low serum IGF-I concentration in obesity is predominantly related to the amount of visceral adipose tissue and not to the amount of subcutaneous fat mass¹³. These findings, together with other endocrine disturbances in central obesity, suggest that the low GH secretion which is observed is secondary to a central disturbance of the neuroendocrine regulation,
10 including the GH/IGF-I axis.

The abdominal/visceral obesity and insulin resistance observed in The Metabolic Syndrome constitute the base for hypertension, dyslipoproteinemia and non-insulin dependent diabetes mellitus.¹

Replacement therapy with recombinant human GH (rhGH) has demonstrated
15 favorable effects on most of the features of GH deficiency in adults¹⁷. Whether rhGH treatment can improve the metabolic abnormalities observed in abdominal/visceral obesity has never been investigated. In the present study a randomized, double-blind, placebo-controlled design was used to evaluate the effects of rhGH administration in patients with abdominal/visceral obesity
20 In the present study thirty men, 48 to 66 years of age with abdominal/visceral obesity were treated with recombinant human GH (rhGH) in a 9-month randomized, double-blind, placebo-controlled trial. Body fat was assessed from total body potassium and abdominal subcutaneous and visceral adipose tissue was measured using computed tomography. Glucose disposal rate (GDR) was
25 measured during euglycemic, hyperinsulinemic glucose clamp.

Legends to figures.

Figure 1. Mean total body fat calculated from total body potassium, abdominal subcutaneous adipose tissue (AT) area at the level of L4-L5 and volume of visceral AT.

- 5 Figure 2. Abdominal subcutaneous and visceral adipose tissue determined with computed tomography at the level of L4-5 in one man before (A) and after 9 months of rhGH treatment (B).

Figure 3. Mean fasting blood glucose, serum insulin and glucose disappearance rate (GDR).

10 EXAMPLE

Subjects and methods

Patients

- Thirty men (48 to 66 years of age) were studied (Table 1). They were recruited by advertisement in a local newspaper. The criteria for inclusion in the study were
- 15 age approximately 50 to 65 years with a body mass index between 25 and 35 kg/m², an IGF-I less than 160 µg/L (low normal) ¹⁸ and a waist hip ratio of more than 0.95. The criteria for exclusion were overt diabetes mellitus, previous cardiovascular event or heart disease.

- In the rhGH treated group, two patients were receiving treatment for hypertension
- 20 with both atenolol (100 mg per day) and nifedipin (40 mg per day) and one patient had slight asthma, treated with salmeterol and terbutalin inhalations. In the placebo treated group, one patient had a slight depressive disorder and was receiving paroxetine (10 mg per day). These medications were kept stable during the study period.

Systolic and diastolic blood pressure were measured after 5 minutes of supine rest using the sphygmomanometric cuff method. This measurement was repeated after one minute and the mean value was used.

Total-body potassium was measured by counting the emission of 1.46 MeV gamma-radiation from the naturally occurring ^{40}K isotope in a high-sensitive 3π whole body counter with a coefficient of variation (CV) of 2.2%. Fat-free mass (FFM) was estimated by assuming a potassium content of 64.7 mmol/kg FFM ¹⁹ and body fat (BF) was calculated as body weight-FFM. A five-scan computed tomography technique was used (Philips Tomoscan 350) to measure abdominal adipose tissue. The five levels were derived from two scanograms and included one scan at the level of the mid-thigh with the lower edge of symphysis as a reference point. The other four levels were the lower edge of symphysis, L4-5 lumbar disc, L3-4 lumbar disc and a scan at the level of liver and spleen. The tissue areas and anatomic boundaries were determined as described previously ²⁰. Total volume of visceral adipose tissue was determined from the five-scan model. Sagittal diameter and abdominal subcutaneous and visceral adipose tissue areas were determined at the level of L4-5.

A euglycemic, hyperinsulinaemic glucose clamp was performed after an overnight fast as previously described ¹⁴. In brief, insulin was infused together with glucose into a venous catheter with the tip at the level of the axillary vein at appropriate rates to obtain submaximal insulin concentrations. Blood glucose concentrations were monitored every 10 min. and glucose infusion rate was adjusted to fasting levels. Glucose disappearance rate (GDR) was measured for 20 minutes in steady-state conditions, which was reached after 100 min. The insulin concentrations during steady state were $214 \pm 10 \mu\text{IU/mL}$ before treatment, $226 \pm 12 \mu\text{IU/mL}$ at 6 weeks and $213 \pm 11 \mu\text{IU/mL}$ at 9 months. During the clamp, in steady-state conditions, a subcutaneous abdominal adipose tissue biopsy was obtained by

needle aspiration for the determination of lipoprotein lipase (LPL) activity. The needle aspiration was performed under local anesthesia, 0.1 m lateral to the umbilicus. The biopsies were immediately frozen in liquid nitrogen and stored at -80-C until assay.

5 Analytic methods

Total LPL activity in adipose tissue was determined after homogenization of the tissue in the detergent-containing buffer as described previously ²¹. Bovine skim milk was used as a standard to correct for interassay variation. The amount of triglycerides (TG) in the tissue was measured after extraction ²² and weighed after
10 evaporation of solvents. Activity was expressed in milliunits (1mU=1 mmol FFA released per min.) per gram adipose tissue and per gram TG. Control experiments showed that the assay was linear with the amount of sample and incubation time over the range used. The within-assay CV was 4.3%.

Blood samples were drawn in the morning after an overnight fast. The serum
15 concentration of insulin-like growth factor-I (IGF-I) was determined by a hydrochloric acid-ethanol extraction radioimmunoassay using authentic IGF-I for labeling (Nichols Institute Diagnostics, San Juan Capistrano, CA, USA) with within-assay CV of 2.5% and 4.2% at serum concentrations of 125µg/L and 345µg/L respectively. The standard deviation score for IGF-I was then calculated
20 from predicted IGF-I values adjusted for age and sex obtained from the normal population ¹⁸.

The insulin-like growth factor binding protein-3 (IGFBP-3) concentration in serum was determined by radioimmunoassay (Nichols Institute Diagnostics) with total CV of 6.2% and 5.7% at serum concentrations of 2.05 mg/L and 3.49 mg/L
25 respectively.

Serum cholesterol and triglyceride concentrations were determined with enzymatic methods (Boehringer, Mannheim, Germany). The within-assay CV for total cholesterol and triglyceride determinations was 0.9% and 1.1% respectively.

Fibrinogen was measured according to a syneresis method ²³ with a total CV of 4% at 2.5 g/L. Plasminogen activator inhibitor (PAI)-1 activity was measured using a Spectrolyse (pL) PAI kit (Biopool Stabilyte, Umeå, Sweden) with a total CV of 10% at concentrations between 10-40 IU/ml.

Serum insulin was determined by a radioimmunoassay (Phadebas, Pharmacia, Uppsala, Sweden) and blood glucose was measured by the glucose-6-phosphate dehydrogenase method (Kebo Lab, Stockholm, Sweden). Hemoglobin A1c (HbA1c) was determined by high pressure liquid chromatography (Waters, Millipore AB, Sweden) and C-peptide was determined by a radioimmunoassay (Santec, USA). Free fatty acids (FFA) levels were determined using an enzymatic colorimetric method (NEFAC; Wako, Neuss, Germany), while sex hormone binding globulin (SHBG) was measured by an immunoradiometric assay (Farnos, Diagnostica, Åbo, Finland) and total testosterone by a radioimmunoassay (ICM, Biomedical, Costa Mesa, USA).

Statistical methods

All descriptive statistical results are presented as the means and standard error of the mean (SEM). Comparisons between the two treatment groups were performed by a two-way analysis of variance (ANOVA) for repeated measurements. Comparisons between baseline values and values at 9 months in the two groups were performed with the Students' t-test for independent groups. Correlations were sought by calculating the Pearson linear correlation coefficient. Pearson's chi square test was used to test the independence of frequency of hypertension and smoking between the rhGH and placebo treated groups. Before statistical analysis.

logarithmic transformation of data with skewed distribution was performed. A two-tailed probability value of less than 0.05 was considered significant.

Results

The two groups were matched with regard to age, body height, body weight and waist hip ratio, and did not differ significantly regarding number of subjects with medically treated hypertension (Chi sqr.=1.87; p=0.17) and current smokers (Chi sqr.=1.2; p=0.27) (Table 1). At baseline the two groups did not differ significantly from each other in any of the variables studied.

Body composition

The patients' mean overall body mass index and fat-free mass did not change while mean total body fat decreased by $9.2 \pm 2.4\%$ during rhGH treatment in comparison with placebo treatment (Figure 1). Waist circumference and sagittal diameter decreased in response to rhGH while no change occurred in the placebo group. Moreover, abdominal subcutaneous and visceral adipose tissue area at the level of L4-5 decreased in response to rhGH by $6.1 \pm 3.2\%$ and $18.1 \pm 7.6\%$ respectively (Figure 1 and Table 2). The corresponding values in the placebo group were $+2.0 \pm 2.8\%$ and $-3.2 \pm 7.6\%$ respectively. Moreover, the volume of visceral adipose tissue decreased in the rhGH treated group by $17.9 \pm 3.5\%$ while no change was observed in the placebo treated group ($-0.2 \pm 4.2\%$) (Figure 1).

Thus, the percentage of visceral adipose tissue of the total adipose tissue at the level of L4-5 decreased by $14.5 \pm 3.8\%$, while the percentage of subcutaneous adipose tissue of the total adipose tissue at the level of L4-5 increased by $5.4 \pm 1.7\%$ in the rhGH-treated group.

Abdominal subcutaneous and visceral adipose tissue was determined with computed tomography at the level of L4-5 in one man before (A) and after 9

months of rhGH treatment (B). The scan showed a reduction of both visceral and subcutaneous adipose tissue . (Figure 2)

Glucose metabolism

No significant effects were elicited by rhGH treatment on blood glucose, serum
5 insulin and HbA1c (Table 3 and Figure 3). The serum concentration of C-peptide increased in the rhGH treated group due to a transient increase at 6 weeks, but the C-peptide level was similar in the two groups at 9 month.

In the rhGH treated group the GDR showed an initial decrease after 6 weeks of treatment followed by an increment while the placebo-treated group
10 demonstrated a slight reduction over time (Figure 3). The average increase in GDR in response to 9 months of rhGH was 1.2 ± 0.7 mg/kg/min compared with baseline while in the group receiving placebo a slight decrease by 0.4 ± 0.6 mg/kg/min occurred. This difference between the two groups was still found after correcting the GDR for the amount of fat-free mass.

15 In the rhGH treated group, an inverse correlation was found between the change in GDR and change in serum triglyceride concentration ($r=-0.58$; $p<0.05$) but no significant correlations were found between the change in GDR and changes in serum IGF-I concentration ($r=-0.24$), serum insulin concentration ($r=-0.27$), LPL activity ($r=0.09$), diastolic blood pressure ($r=-0.30$), total body fat ($r=-0.06$) and
20 volume of visceral adipose tissue ($r=-0.11$).

Total cholesterol, triglycerides, LPL activity, plasma fibrinogen and PAI-1 activity (Table 3)

The mean total cholesterol concentration decreased from 6.1 ± 0.2 to 5.4 ± 0.3 mmol/L and the triglyceride concentration decreased from 2.09 ± 0.29 to $1.78 \pm$
25 0.23 mmol/L in response to rhGH treatment. The corresponding changes in the

placebo group were from 5.4 ± 0.3 to 5.5 ± 0.2 mmol/L and from 1.65 ± 0.13 to 2.05 ± 0.26 mmol/L respectively.

The mean total LPL activity in subcutaneous abdominal tissue did not change during rhGH treatment in comparison with placebo treatment. However, between
5 6 weeks and 9 months, LPL activity tended to increase in the rhGH treated group as compared with the placebo treated group ($p=0.06$). Similar results were obtained when LPL activity was expressed in mU/g TG.

The plasma concentration of fibrinogen increased in response to rhGH while PAI-I activity was unaffected by rhGH treatment as compared with placebo.

10 Blood pressure and heart rate

Diastolic blood pressure decreased from 75 ± 2 to 70 ± 2 mmHg in the rhGH treated group. The corresponding values in the placebo group were from 73 ± 2 to 74 ± 2 mmHg ($p<0.05$). No significant effects on systolic blood pressure or heart rate were observed between the two treatment groups.

15 Serum IGF-I, IGFBP-3, testosterone and SHBG (Table 4)

Before treatment, the serum IGF-I concentration was low normal in both treatment groups. A significant increment in serum IGF-I and IGFBP-3 concentrations occurred in the rhGH treated group as compared with placebo treatment. At 6
20 weeks, the serum IGF-I concentration reached on average 3.30 ± 0.35 SD above the predicted mean in the rhGH treated group while at 9 month the mean serum IGF-I concentration was 1.89 ± 0.48 SD above the predicted mean. Serum concentrations of testosterone and SHBG were not significantly affected by rhGH treatment.

Side-effects

No drop-outs occurred during the study. Side-effects were observed in 8 subjects in the rhGH treated group, and were mainly a result of fluid retention. Five had peripheral edema, two subjects experienced muscle stiffness and arthralgia, one developed mild carpal tunnel syndrome and one subject experienced increased perspiration. These side-effects appeared during the first 6 weeks of treatment and subsided in four patients in response to a reduction in dose performed within 4 months after start of treatment; in three patients, the side-effects subsided spontaneously. One man from the rhGH treated group with medically treated hypertension was taken off treatment after 8 months when he experienced an intracerebral hemorrhage. Three subjects in the placebo group experienced slight and transient peripheral edema.

Legends to figures.

Figure 1.

Mean total body fat calculated from total body potassium, abdominal subcutaneous adipose tissue (AT) area at the level of L4-L5 and volume of visceral AT assessed with computerized tomography during 9 months of treatment with rhGH or placebo in 30 men with abdominal/visceral obesity. The horizontal bars indicate the SE for the mean values shown and p-values denotes the differences between the two groups by two-way ANOVA for repeated measurements.

Figure 2.

Abdominal subcutaneous and visceral adipose tissue determined with computed tomography at the level of L4-5 in one man before (A) and after 9 months of rhGH treatment (B). The scan shows the reduction of both visceral and subcutaneous adipose tissue (shown as dark gray area in the figure).

Figure 3.

Mean fasting blood glucose, serum insulin and glucose disappearance rate (GDR) assessed with euglycaemic hyperinsulinaemic glucose clamp during 9 months of treatment with rhGH or placebo in 30 men with abdominal/visceral obesity. The horizontal bars indicate the SE for the mean values shown and p-values denotes the differences between the two groups by two-way ANOVA for repeated measurements.

Discussion

We have shown that 9 months of rhGH treatment in middle-aged men with abdominal/visceral obesity reduced total body fat and resulted in a specific and marked decrease of both abdominal subcutaneous and visceral adipose tissue. Insulin sensitivity assessed with euglycemic glucose clamp technique improved and serum concentrations of total cholesterol and triglyceride decreased. Furthermore, diastolic blood pressure decreased.

The men who were studied were moderately obese with a preponderance of abdominal and/or visceral localization of body fat as judged from comparisons with randomly selected men of comparable age from the same city ²⁴. As a group, they had slight to moderate metabolic changes known to be associated with abdominal/visceral obesity with moderate insulin resistant as judged from the GDR values obtained during the euglycemic glucose clamp, although no one had overt diabetes.

Although, we used a lower daily rhGH dose than previously reported in trials studying healthy adults ^{25, 26}, the initial rhGH doses administered were apparently too high as judged by the frequency of side-effects and initial high average serum IGF-I concentrations. After dose reduction the average serum IGF-I concentration where within the normal range indicating that the doses of rhGH

during the latter part of the study were more physiological. This might in turn explain the less marked anabolic action of the rhGH treatment demonstrated in this study in comparison with previous trials in healthy adults ^{25, 26}.

The marked effect of GH replacement on body composition in GH-deficient adults
5 has been a consistent observation in many studies ¹⁷. The profound lipolytic effect of GH was also demonstrated in the present study with a preferential reduction in visceral adipose tissue depots ²⁷. These changes have been associated with a GH-induced reduction in the antilipolytic effects of insulin, which is markedly different in different adipose tissue regions ²⁸.

10 GH exerts direct insulin-antagonistic effects even after the administration of physiological doses of rhGH. GH has been considered to be the principal factor in the decrease in insulin sensitivity observed in the early morning, the so called "dawn phenomenon" ²⁹ and the insulin resistance following hypoglycemia ³⁰. Thus, our observation of increased insulin sensitivity during prolonged rhGH
15 treatment is unexpected. We have previously shown that 6 weeks of rhGH treatment in GH-deficient adults only induced a temporary decrease in insulin sensitivity which after 6 months of treatment was restored to baseline values ³¹. The response of GDR to rhGH treatment on in this trial showed a similar initial tendency to induce insulin resistance but after 9 months a marked improvement
20 was found.

GH has been found to be an important regulator of the hepatic LDL-receptor ³⁵ and the overall lipoprotein metabolism ³⁶. The reduction in total cholesterol is conceivable an effect of enhanced hepatic LDL receptor activity in response to GH³⁵. In healthy adults, short-term rhGH administration has been reported to
25 increase serum triglyceride concentration ²⁵. In this study, the serum triglyceride concentration also displayed an initial increase in response to rhGH treatment. This could be an effect of both an increased flux of FFA to the liver and a direct

stimulatory effect on the esterification of oleic acid into triglyceride and phospholipids in hepatocytes ³⁷ in response to GH which in turn enhances the very low density lipoprotein production from the liver. However, after 9 months of rhGH treatment serum triglyceride concentration had decreased again, probably as an effect of the increased insulin-stimulated glucose uptake which is known to be inversely related with the very low density lipoprotein secretion rate from the liver and serum triglyceride levels ⁴.

The initial tendency of a decline in LPL activity observed in the present study is in accordance with a previous 2 weeks treatment trials with rhGH ³⁸. During the more prolonged rhGH treatment, however, LPL activity tended to increase which may, at least in part, explain the decrease in serum triglyceride concentration at 9 months. The changes in GDR and LPL activity showed a similar biphasic pattern in response to GH. It may thus be speculated that the suggested influence of GH on LPL activity is mediated through insulin sensitivity, since insulin is known to be a potent stimulator of LPL.

Nine months of rhGH treatment reduced diastolic blood pressure without affecting systolic blood pressure. This is in line with results from GH-deficient adults where rhGH administration reduced diastolic blood pressure possibly as an effect of reduced peripheral vascular resistance ³⁹. The mechanisms behind the reduction in peripheral vascular resistance might be indirect through the reduced abdominal obesity and increased insulin sensitivity ⁴⁰ or more direct through the action of IGF-I on the vascular wall ⁴¹.

Abdominal/visceral obesity is associated with increased plasma fibrinogen concentration and PAI-1 activity ^{42, 43} which both are established risk factors for myocardial infarction and stroke ^{44, 45}. The slightly increased plasma fibrinogen concentration in response to GH may be mediated through increased serum IGF-I concentration ¹⁸. In GH-deficient adults, 2 years of rhGH treatment tended to

decrease plasma fibrinogen levels and diminish PAI-1 activity ⁴⁶. This further illustrates the importance of the duration of rhGH treatment on the metabolic effects of GH.

Previous studies have shown that testosterone treatment of middle-aged men with abdominal/visceral obesity induced improved insulin sensitivity, plasma lipid
5 levels, diastolic blood pressure as well as a specific decrease of visceral adipose tissue mass ^{14, 46}. Since testosterone treatment of men with hypogonadotropic hypogonadism increases GH secretion ⁴⁷ the similarities between testosterone and rhGH treatment might be explained by increased GH levels or by additive or
10 synergistic effects of GH and testosterone on adipose tissue metabolism ⁴⁸.

The multiple endocrine alterations associated with abdominal/visceral obesity can either be primary responsible or be the consequence of the obese condition. This is the first trial clearly to demonstrate favorable effects of GH on the multiple perturbations associated with abdominal/visceral obesity. We therefore suggest
15 that a blunted GH secretion could be an important factor in the development of the metabolic and circulatory consequences of abdominal/visceral obesity. The metabolic effects demonstrated in this study are probably of importance for the risk of cardiovascular morbidity and mortality in men with abdominal and central adiposity.

Table 1.

Clinical characteristics of the cohort of 30 men treated with GH or placebo for
5 9 months.

Patient characteristics	GH	Placebo
Number of men	16	14
Mean age (range); years	58.3 (48-66)	57.9 (52-63)
Treated hypertension; no.	2	0
Present smokers; no.	5	2
Body height; m	1.80±0.02 *	1.77±0.02
Body weight; kg	101.7±2.4	96.2±2.6
Waist hip ratio	1.01±0.01	1.03±0.02

* Plus-minus values are means ± standard error of the mean.

Table 2.

Measurements of body mass index (BMI), fat free mass, waist circumference, sagittal
 5 diameter and abdominal visceral adipose tissue (AT) area at the level
 of L4-5 in 30 men, during 9 months of rhGH or placebo treatment.

Variable	Baseline	6 weeks	6 months	9 months	p #
BMI; kg/m²					
GH	31.4±0.7	31.6±0.7	31.3±0.7	31.1±0.8	0.2
Placebo	30.5±0.8	30.6±0.7	30.5±0.8	30.7±0.8	
Fat free mass; kg					
GH	67.5±1.8	69.7±1.9	71.1±1.8	69.5±2.2	0.4
Placebo	64.6±1.4	65.2±1.4	66.4±1.3	65.3±1.4	
Waist; cm					
GH	111.8±1.8	110.8±1.8	107.6±1.7	109.8±1.9	0.002
Placebo	109.5±2.5	109.4±2.4	109.3±2.3	111.0±2.3	
Sagittal diameter;cm					
GH	26.1±0.5	25.9±0.5	25.2±0.5	25.0±0.6	0.03
Placebo	25.5±0.7	25.3±0.8	24.6±0.9	25.5±0.8	
Visceral AT; cm²					
GH	126±15	121±19	98±14	99±15	0.004
Placebo	163±16	147±13	142±12	150±13	

10 All values are expressed as the mean (SEM).

P-values denote the differences between the two groups by two-way ANOVA
 for repeated measurements.

Table 4.

Measurements of serum IGF-I, IGFBP-3, free fatty acids (FFA), testosterone and steroid hormone binding globulin (SHBG) in 30 men, during 9 months of GH/placebo treatment.

Variable	Baseline	6 weeks	6 months	9 months	p #
IGF-I; $\mu\text{g/L}$					
GH	134 \pm 8	338 \pm 16	320 \pm 23	268 \pm 23	<0.001
Placebo	120 \pm 11	121 \pm 11	129 \pm 12	119 \pm 12	
IGF-I SD score *					
GH	-0.82 \pm 0.17	3.30 \pm 0.35	2.91 \pm 0.49	1.89 \pm 0.48	<0.001
Placebo	-1.07 \pm 0.23	-1.04 \pm 0.23	-0.87 \pm 0.24	-1.08 \pm 0.25	
IGFBP-3; mg/L					
GH	2.36 \pm 0.13	3.20 \pm 0.10	3.19 \pm 0.13	2.71 \pm 0.14	0.001
Placebo	2.10 \pm 0.16	2.21 \pm 0.17	2.45 \pm 0.21	2.18 \pm 0.19	
FFA; $\mu\text{mol/L}$					
GH	0.77 \pm 0.07	0.99 \pm 0.11	0.78 \pm 0.11	0.75 \pm 0.07	0.5
Placebo	0.73 \pm 0.05	0.73 \pm 0.05	0.59 \pm 0.06	0.67 \pm 0.05	
Testosterone; nmol/L					
GH	14.6 \pm 1.2	12.9 \pm 1.0	13.9 \pm 1.3	12.4 \pm 1.1	0.12
Placebo	14.6 \pm 1.0	15.4 \pm 1.2	17.6 \pm 2.1	14.6 \pm 1.3	
SHBG; nmol/L					
GH	26.4 \pm 3.4	25.5 \pm 3.5	25.9 \pm 3.1	23.4 \pm 2.8	0.8
Placebo	28.1 \pm 2.9	29.1 \pm 3.1	29.2 \pm 3.2	25.5 \pm 2.7	

10 All values are expressed as the mean (SEM).

P-values denotes the differences between the two groups by two-way ANOVA for repeated measurements.

* The standard deviation score for serum IGF-I is calculated from predicted IGF-I values adjusted for age and sex obtained from the normal population¹⁸.

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